Conductivity-Temperature-Depth Profiling of the Columbia River Mouth Using Pacific Harbor Seals as Sampling Platforms

Robin F. Brown
Oregon Department of Fish and Wildlife
7118 NE Vandenberg Ave.
Corvallis, OR 97330
phone: (541) 757-5245 fax: (541) 757-4252 email: robin.f.brown@state.or.us

Steve J. Jeffries
Washington Department of Fish and Wildlife
7801 Phillips Road SW
Lakewood, WA 98498
phone: (253) 589-7235 fax: (253) 589-7180 email: steven.jeffries@dfw.wa.us

Bryan E. Wright
Oregon Department of Fish and Wildlife
7118 NE Vandenberg Ave.
Corvallis, OR 97330
phone: (541) 757-5225 fax: (541) 757-4252 email: bryan.e.wright@state.or.us

Award Number: N000141310145

LONG-TERM GOALS

The long-term goal of this study is to assess the feasibility of using pinnipeds as autonomous sampling platforms to collect oceanographic data for use in predicting the dynamics of nearshore, estuarine, and riverine environments.

OBJECTIVES

The specific objectives of this study are to use harbor seals to collect georeferenced conductivity, temperature, and depth data for use in modeling the dynamics of the Columbia River Mouth.

APPROACH

Marine animals have increasingly been used as sampling platforms to collect oceanographic information (Boehlert et al. 2001, Fedak 2004). These "animal oceanographers" have included sea turtles (e.g., McMahon et al. 2005), penguins (e.g., Charrassin et al. 2002), sharks (e.g., Weng et al. 2003), and marine mammals (e.g., Costa et al. 2008, Laidre et al. 2010). We used the latter group, specifically harbor seals (*Phoca vitulina*), to sample oceanographic data in the Columbia River for use by other researchers in the RIVET DRI. We chose to use harbor seals as sampling platforms because they are considered non-migratory, central-place foragers that typically forage within 50 km of haul-out sites (Thompson and Miller 1990, Thompson et al. 1991).

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
30 SEP 2013		**00-00-2013 to 00-00-2013**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Conductivity-Temperature-Depth Profiling of the Columbia River Mouth Using Pacific Harbor Seals as Sampling Platforms	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Oregon Department of Fish and Wildlife,7118 NE Vandenberg Ave,Corvallis,OR,97330**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Same as Report (SAR)**	**8**	

Location, temperature, and depth data were collected using GPS-phone tags (Sea Mammal Research Unit (SMRU), St. Andrews, Scotland). These tags contained a GPS receiver, pressure sensor (resolution: 0.5 m at surface, 5 m at 2000 m), wet/dry saltwater switch, real-time clock, and a temperature sensor (resolution: 0.1 °C). Data was stored in memory and periodically uploaded through the cellular phone network. Tags were attached to seals using 5-min epoxy and placed mid-dorsum. We previously had deployed these tags on California sea lions and Steller sea lions in the Columbia River during 2011 and 2012 (e.g., see Brown et al. 2011). In addition to GPS-phone tags, a subset of five seals were given a second instrument package consisting of a VHF radio tag (Advanced Telemetry Systems, Minnesota, USA) and a conductivity-temperature-depth (CTD) tag (Star-Oddi, Iceland). These two tags were potted in syntactic foam which allows the tags to float to aid in their recovery. Use of CTDs will allow for direct estimation of salinity and will be linked to the GPS sensor data based on the timestamps of the two tags.

Key individuals involved in this project included Robin Brown from the Oregon Department of Fish and Wildlife (PI), Steve Jeffries from the Washington Department of Fish and Wildlife (CO-PI), and Bryan Wright from the Oregon Department of Fish and Wildlife (CO-PI).

WORK COMPLETED

We successfully deployed GPS-phone tags on 15 harbor seals captured at Desdemona Sands near the Columbia River Mouth on May 29-30, 2013; a subset of 5 of these harbor seals also received archival CTD instrument packages (see Figure 1). As of September 30, 2013, all the GPS-phone data had been received, and one of the five CTD tags had been recovered (an additional CTD tag was reported found by the public but has not yet been returned).

Figure 1: Harbor seal with GPS-phone tag (green tag on right) and archival CTD tag (housed in orange flotation on left).

RESULTS

GPS-phone tags

GPS-phone tag longevity varied among seals, ranging from approximately 20 to 74 days (Table 1). Tag longevity was presumably a function of the molt, with females molting earlier than males, although it is possible that some tags malfunctioned or ran out of battery before becoming detached.

As expected, seals remained in and around the lower Columbia River estuary most of the time, though some seals made trips to and from Willapa Bay and Grays Harbor in Washington (Figure 2). GPS fixes ranged from 6.6 to 77.7 per day (Table 1). This was less than expected and may have been due to tags not breaking the surface of the water as often as expected and/or problems with the tag's wet/dry sensor falsely indicating the tag was still submersed in water. While there were location gaps in foraging track lines, the relatively shallow maximum depths per seal (Table 1) show that most seals did not travel far from estuarine or nearshore habitats. Temperature upcasts ranged from 10.1 to 301.5 profiles per day (Table 1) and were transmitted for approximately 58% of all 170,220 dives.

An example of this data is shown in Figure 3 which summarizes movements and dive data for a single seal over a 24 hour period. The time period in this example is from 1:00 a.m. on June 8 to 1 a.m. on June 9 (the 1 hour offset from the calendar day is due to the tag being set to Greenwich Mean Time and the activity data being binned in 2-hour time blocks). From top to bottom, the four main panels depict location, activity budget, tide cycle, and dive-temperature profiles. In the top panel, the open circles depict GPS location fixes and the colored circles joining the open circles are straight-line interpolated dive locations showing the inferred track of this seal. The open triangles depicts where the animal hauled out, which in this case is Desdemona Sands where it was originally captured. The panel immediately below the map summarizes the animal's activity budget over each 2-hour time block. Categories include percent of time hauled out, at the surface, and diving greater than 1.5 m. Below the activity budget is a simple graph of tide height. The final panel depicts dive (black lines) and temperature (colored filled circles) profiles. These profiles can be matched to locations in the map based on the color ramp atop the panel which corresponds to the interpolated dive locations in the map. (The open circles atop the last panel depict the GPS fixes on the map and the horizontal lines depict haul-out bouts.) Note that only a fraction of dive locations have GPS fixes and not all dives have temperature upcasts.

Archival CTD tags

As of September 30, 2013 one of the five archival CTD tags had been recovered and an additional CTD tag was reported found by the public but has not yet been returned. Data summary and analysis is pending.

Table 1. Summary of data collected from GPS-phone tags.

Deployment					Dives			GPS fixes		Temperature upcasts	
Animal ID*	Tag ID	Start	End**	Duration (d)	Mean per day	Total	Maximum depth (m)	Mean per day	Total	Mean per day	Total
F-A252-017	205	5/29/13	7/2/13	34	320.1	11,203	20	74.2	2,449	65.3	2,091
F-A254	807	5/29/13	6/21/13	23	222.0	5,328	24.3	51.6	1,186	75.5	1,736
F-A255	810	5/29/13	7/6/13	38	184.3	7,186	21.5	63.2	2,400	116.8	4,438
F-A256	806	5/29/13	6/18/13	20	164.5	3,289	18	67.7	1,422	62.8	1,068
F-A257	801	5/29/13	6/29/13	31	101.2	3,136	22	63.8	2,043	22.6	339
F-A258	809	5/29/13	6/23/13	25	98.0	2,450	81.6	76.3	1,756	94.3	1,132
F-A264	808	5/30/13	6/23/13	24	87.5	2,101	16	77.7	1,943	34.5	517
F-A267	804	5/30/13	6/21/13	22	51.5	1,082	21.5	71.7	1,578	10.3	124
M-A259-056	802	5/29/13	7/29/13	61	268.6	16,382	76.6	21.9	854	145.9	8,755
M-A260-036	201	5/29/13	7/19/13	51	323.6	16,506	46.1	6.6	322	269.3	13,733
M-A261-097	203	5/29/13	7/25/13	57	342.2	19,508	28.3	26.6	1,514	301.5	17,187
M-A262-075	204	5/29/13	8/8/13	71	337.8	24,322	37.6	30.4	1,094	260.7	18,768
M-A263	202	5/29/13	6/30/13	32	314.9	10,077	38.6	24.0	649	66.8	1,871
M-A266	803	5/30/13	8/12/13	74	298.4	22,081	137.4	23.1	1,526	210.4	15,572
M-A268	805	5/30/13	8/10/13	72	355.1	25,569	39.1	20.3	1,378	173.7	11,812
Total				635		170,220			22,114		99,143

*F=female; M=male; seals with additional three-digit number are animals that were also tagged with archival CTD tags.

**End date is approximate since some tags kept transmitting after detaching from seal.

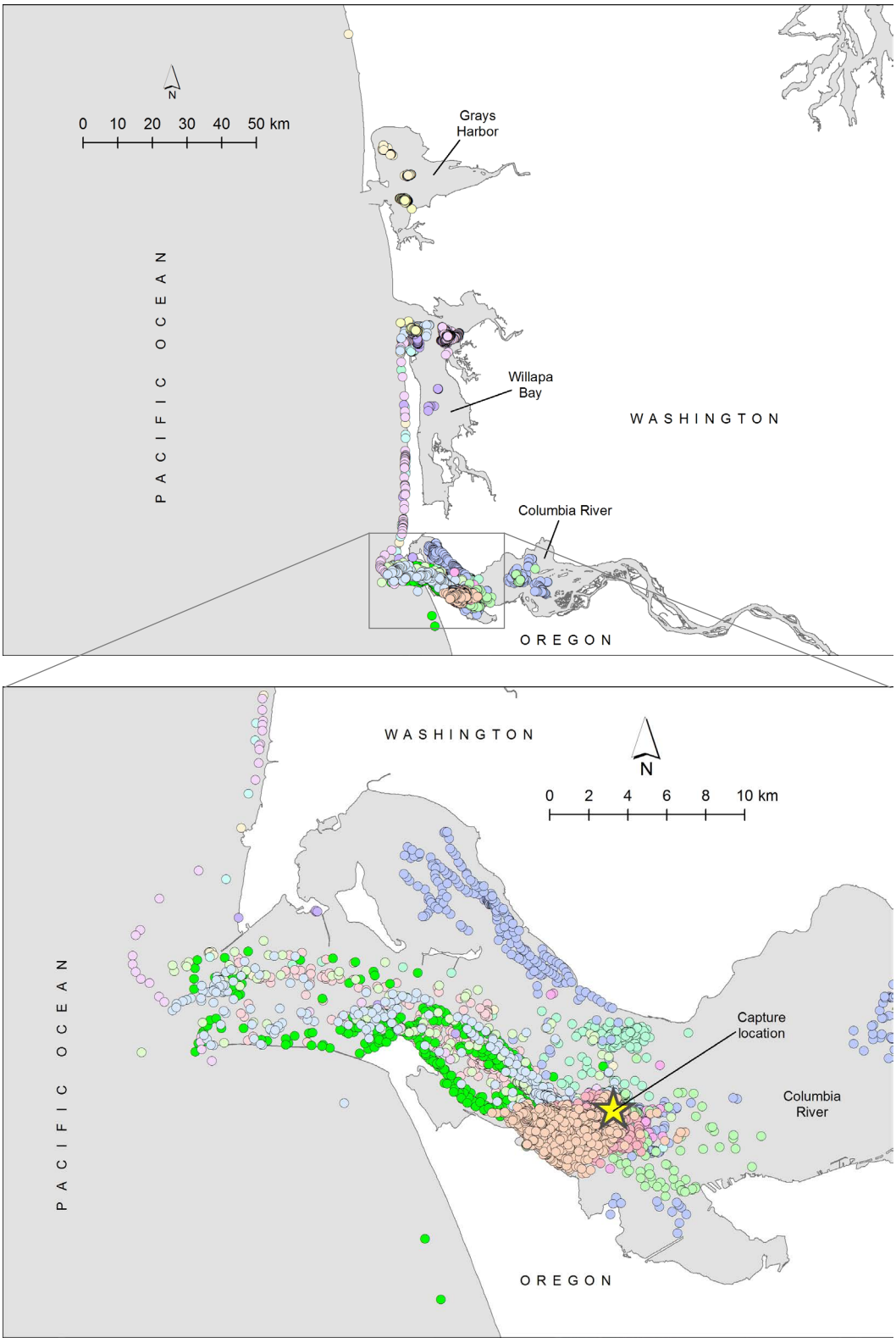

Figure 2: Location fixes from GPS-phone tags attached to 15 harbor seals captured at the Columbia River Mouth on May 29-30, 2013. Each color depicts a different seal.

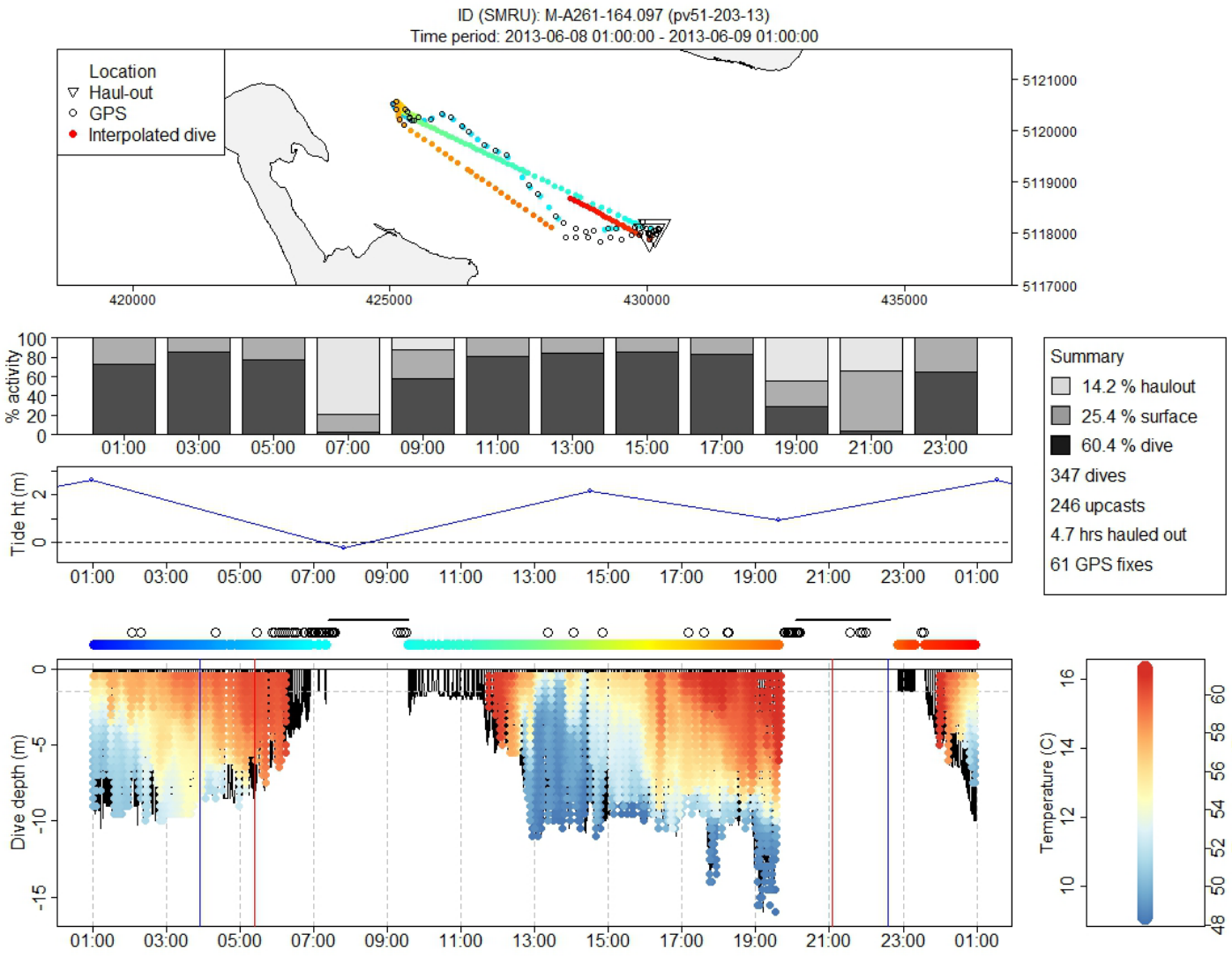

Figure 3: Example 24-hour summary of movements and tag data from a harbor seal tagged at the Columbia River Mouth. Top panel shows actual and inferred animal locations, second panel shows two-hour activity budget summaries, third panel shows tide height, and last panel shows dive profiles overlaid with temperature upcasts.

IMPACT/APPLICATIONS

Use of marine animals as platforms for oceanographic sampling has been called a "win/win" for marine biologists and oceanographers (Fedak 2004). Marine animals can collect oceanographic data at fine spatio-temporal scales, from areas that are logistically difficult to sample, and at a relatively low cost. This information can be used to both better understand the habitat needs of the animal and at the same time provide data for building predictive models of the nearshore, estuarine, and riverine environment. This project demonstrated the proof of concept for using harbor seals to target the study of relatively small and specific areas such as a constricted river mouth.

RELATED PROJECTS

There are two projects closely related to this one under the current RIVET DRI. One project (Roby, Oregon State University) uses seabirds as animal sampling platforms and the other project (Lerczak, Oregon State University) involves the actual analysis of the oceanographic data collected by the seabird and pinniped sampler projects.

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